1. Major Changes
2. Revisions Required in The Summary Review
3. Create better scenarios
   1. *[R4] The video illustrated a rather simple star-substructure network, but that would necessarily require such complicated setup but simply a degree calculation. A more interesting use case would have helped a lot.*

Revision:

1. Improve supplementary material
   1. *[R2] The video would greatly improve with narration, and an intro.*

Revision: Thank you for your advice. We add narration and an intro in the video.

* 1. *[R3] The supplementary material should contain a voice-over for publication.*

Revision: Thank you for your advice. We add voice into the video.

* 1. *[R4] The supplemental material, the video, seems to be accelerated and it is not clear if the querying and results are real-time or not.*

Revision: Thank you for your advice. The video is accelerated because we want to control the time of the video. We revise a part the video to the origin speed to show the querying and results in real time.

1. Improve discussion
   1. *[R1] While the workflow intuitively makes sense, further discussions about the theoretical guarantees ensuring a good exemplar being suggested is required. It fairly seems like a completely automated approach, however, there seems to be manual tuning like, "a connected component is filtered out automatically if its size is too small (|C|/|gs| < 50%) or it cannot be mapped to the exemplar properly (|PC|/|Ps| < 50%)."*

Revision: Thank you for your advice. We add section 5.6 to introduce the manual tuning of the quality of suggested exemplars. We also discuss the quality of exemplars in discussion.

* 1. *[R2] Can this method be extended to dynamic networks (i.e., networks that change over time), what would be the implications? The network sketching would be different, the overall network visualization etc. what else would change, and do you think this can be done such that it is still this interactive and intuitive?*

Revision: Thank you for your advice. We discuss the extension of our method to other types of network, including multivariate networks and dynamic networks in discussion. We think it is possible to extend our method to dynamic networks. Two aspects of efforts should be done. First, a vector representation design for dynamic networks is required, which can translate the dynamic contexts of nodes into vectors. Second, the visualization should be re-designed to show the dynamics of the network and the interactions of specifying exemplar both in the node-link view and the sketch view should be re-designed to enable users to specify an exemplar that is changing along time. We plan to extend our method to other types of network in the future.

* 1. *[R2] Why is the method limited to networks that are undirected and do not contain any self-loops and multiple edges? Is this a limitation of the matching algorithm? Are there algorithms that can deal with less constraints? What would be the performance hit?*

Revision: Thank you for your advice. We discuss the potential of extending our method to other type of networks in discussion. Our method is limited to networks that are undirected unweighted networks without self-loops and multiple edges because the vectorized representations we used are designed for such networks. By modifying the representation, our matching algorithm is potentially able to deal with other types of network. We plan to extend our method to other types of network in the future.

* 1. *[R2] The method demands that the networks are translated to vectors. It seems this is already pre-computed as stated in section 6. This is no hinderance for the method but it would be good to explain how this is done and how much time it takes for the example bitcoin network given.*

Revision: Thank you for your advice. We describe the how the vectorized representations are calculated in the beginning of section 6 and the time cost of each method.

* 1. *[R4] The discussion section barely talks about the design tradeoffs, implications, value, etc. It is very short and requires significant elaboration.*

Revision:

1. Include missing work
   1. *[R1] The authors mention several works in the related work. However, other major works on the visualizations seem to be missing, some of these include, Purchase, Helen C., Eve Hoggan, and Carsten Görg. "**How important is the “mental map”?–an empirical investigation of a dynamic graph layout algorithm." International Symposium on Graph Drawing. Springer, Berlin, Heidelberg, 2006.*

*Ma, Kwan-Liu, and Chris W. Muelder. "**Large-scale graph visualization and analytics." Computer 46.7 (2013): 39-46.*

Revision: Thank you for your advice. We have included these two works in related work.

* 1. *[R3] The related work is very broad and should be more specific to the problem the paper addresses. There are just too many graph visualizations out there at the moment, and few addressing the problem of subgraph matching. Rather than listing many of them, the related work should carve out the problem with existing approaches to support the main motivation in the paper. Can you tell us more about related automatic approaches based on e.g. subgraph similarity? See e.g. for an example:*

*-* *A System for Interactive Visual Analysis of Large Graphs Based on Motif Analysis T von Landesberger, M Görner, R Rehner, T Schreck - International Fall Workshop on Vision, Modeling, and …, 2010*

Revision: Thank you for your advice, we have expanded the related work to discuss the works that related to automatic approaches.

1. Clarify ‘exemplar’
   1. *[R1] The authors use the word "exemplar" a lot. It would be great to define this term earlier in the manuscript and not in page 3 of the manuscript*

Revision: Thank you for your advice. We explain the term “exemplar” in the the third paragraph in introduction: “Here, we define a structure, or a subgraph, of a network as a relationship among a set of connected nodes and an exemplar as a structure which is specified by users and represents users’ interests during the exploration of networks.”

* 1. *[R2] I think the paper benefits from describing in more detail how the exemplar is specified. Is this really done node by node, edge by edge, or is the user enabled to also define more abstract concepts e.g., give me two dense clusters connected by 2 edges. Or give me all structures where a large dense cluster (> 100 nodes) is connected with two smaller dense clusters (<= 50 nodes).*

Revision: Thank you for your advice. We provide more details about how the exemplar is specified in section 5.2. Currently, the exemplar is specified node by node, edge by edge based on provided templates in the exemplar sketching view or is specified directly by selecting nodes in the node-link view. We plan to achieve specification by abstract concepts in the future as described in the future works.

* 1. *[R4] Section on Specifying Exemplars (4.2), a key component of exploring the network, is very short. Similarly, (5.3) provides almost no insight into this task.*

Revision: Thank you for your advice. We expand section 4.2 and section 5.3. In particular, we introduce two major ways to specify an exemplar in our system, and introduce the interactions supported in the sketching exemplar view and how users can define an exemplar freely in this view. Moreover, we also describe how specifying exemplars in the node-link view and specifying exemplars in the sketching exemplar view are different in section 5.3 and discuss what such difference would affect the quality of suggested exemplars in discussion.

1. Describe/discuss quality of exemplars
   1. *[R1] Also, while the idea is great, it is hard to judge the quality of the suggested "exemplars". How useful are these exemplars? This definitely would vary for different graph types, for e.g., social networks, marketing networks. A brief description of the quality of the methodology would be great.*

Revision: Thank you for your advice. We discuss the quality of suggested exemplars in the discussion. Also, we add section 5.6 to introduce how users can interactively affect the quality of suggested exemplars.

* 1. *[R3] A high-level question that remains to me is how you allow for control over how 'strict' the algorithm is in suggesting patterns. I.e. what control does a user has with respect to controlling a) what is similarity, and b) how similar the suggested structures should be. How do you decide how many 'similar' structures do you find and show? The video shows the interface components (sliders) but I think I could not find them in the paper.*

Revision: Thank you for your advice. We add Section 5.6 to introduce the control panel in the system. With the control panel, users are able to adjust parameters before exemplars are suggested to control the quality of suggested exemplars.

1. Report on search speed
   1. *[R4] Performance evaluation (6.2) is not clear. Since there are no extensive user studies, this section should have been much longer and elaborative. What other approaches could have been used?*

Revision: Thank you for your advice. We extend the performance evaluation (section 6.2) by evaluating the performance of two ways of specifying exemplars based on different size of networks, different size of exemplars, and different vectorized representations separately. In particular, we analyze how performance of our method is affected by the way of specifying exemplars and vectorized representations and which vectorized representation is the best for the two ways of specifying exemplars.

1. Include index terms, below abstract

Revision: We have added index terms below abstract.

1. Other Revisions Required by Reviewers

[R1]

**Review: *I still do not get the motivation of the work, the authors mention that the subgraph matching involves a lot of computational cost. While this is true, I am not sure if this work is aimed at solving this very particular problem the computational cost problem or the visual perceptual network exploration problem.***

Revision:

**Review: *The authors do not mention about edge-cases in specifying the exemplars, how does the system handle exemplars when the user picks all nodes, or exemplar consisting of 60-70% of the graph network?***

Revision:

**Review: *Again, while the idea is good, insights are so much harder to gain from Figure 8 or all figures in general. The number of edge-crossings impedes meaningful interpretation of the data.***

Revision: Thank you for your advice.

[R2]

**Review: *Did the authors do experiments with different network vectors? If so, what worked best, what didn't work etc.?***

Revision: Thank you for your advice. We did experiments with different network vectors and described the result in sec 6.2. We found that Graphwave works best for specification by selection and Graphlet Kernel works best for specification by sketching.

**Review: *As stated the users in the user study all had experience with visualization, but did they also have experience with network exploration (more important imho).***

Revision: Thank you for your advice. We describe their experience with network exploration. All participants have no experience in network exploration.

**Review: *- page 2, section 2.2: van Han -> van Ham***

***- Page 3, Section 4.1: what are networklets?***

Revision: Thank you for your advice. We have revised these two issues.

[R3]

**Review: *Can you explain 'vectorized' in the abstract a little better?***

Revision: Thank you for your advice. We add explanation of vectorized representation in the abstract.

**Review: *From the intro, it is not clear how the contribution of this paper relates to the problem of NP-hardness of finding matching subgraphs. The intro talks about visualization but the problem addressed in this paper is about automatic suggestions of substructure. I think this problem and analytical solution must be highlighted better in the intro and in the related work (see below).***

Revision:

**Review: *Which specific problems do the 5 methods have that you list in Sec 4.1? Why do you need your contribution to amend them? Currently, at the end of the related work, I know that interactive approaches do not scale, but this is clear from the beginning.***

Revision: Thank you for your advice. The 5 methods we list in Sec 4.1 are 5 methods that transform nodes in a large network to vectors based on topology information. We actually do not amend these methods, instead, we test our method based on these vectorized representations and try to find the best representation for the suggestive exploration of large networks. In Sec 6.2, we compare these representations and analyze which one is the best.

**Review: *The motifs in Fig 1e are very small and I wonder why not more space have been dedicated to them? Fig. 7a on the other side is a vector illustration, probably done by hand. How do you show large subgraphs with many nodes?***

Revision: Thank you for your advice. We increase the size of the exemplar glyphs in the exploration history view. We provide a mechanism to prevent the glyph from containing too many nodes. Before visualize the subgraphs, nodes are grouped into different clusters according to the DBScan result of the specified exemplar. Thus, the number of circles in each glyph is controlled.

**Review: *In the user study, some details are missing, e.g. how was time recorded if participants provided their answers on a separate sheet? How did the training function? Which structures did you ask participants to find and how complex have they been? Was there any balancing? how often did they have to find structures? how did you counteract any training effect in finding and learning structures?***

Revision: Thank you for your advice. The description of how participants provide their answers is wrong here and we have corrected the description. Participants can directly record their answers in the system, as shown in the video. (not finished yet)

**Review: *Second, I am not sure it is valid to compare human performance to automated approaches. I think the measure of success for this system is not time and precision, but how much the found structures resemble each other, compared to other automatic baseline approaches.***

Revision:

[R4]

**Review: *Networks are simple, undirected, unweighted. Many large networks are not necessarily like that.***

Revision: Thank you for your advice. Our method currently limits to simple, undirected, and unweighted networks. We plan to extend our method to other types of network in the future.

**Review: *I realize that a user study is not critical, but visual exploration of networks ultimately demands an evaluation of how well user exploration is supported. (7) is very short and not as sophisticated as it should be. Either 6.2 should be better or 7.***

Revision: Thank you for your advice. We expand sec 6.2 by ().

**Review: *I realize that this is not a network visualization tool, but the clutter of the graphs could have been improved through better node/edge styling or some occlusion techniques. It would allow a clearer identification of substructures too.***

Revision: Thank you for your advice. We change the styling of node and edge to improve the network visualization. Specifically,

**Review: *I do like the capability of providing graph suggestions as well as indication where in the graph they may be. However, I struggle with the scalability of this approach as I think there could many of these examples through the graph. For instance, what if I sketch a triad? Without any node information, we lose a lot of important information.***

Revision:

**Review: *The exploration history capability is definitely of value, but in the use case description it is unclear how this could be used. Is there an undo functionality? Could two different searches be saved and compared? Neither one of these are elaborated.***

Revision: Thank you for advice. We add description of how the exploration history is used to review the exploration history. We also add an example showing how this view works during the exploration.